OVERVIEW OF THERMAL BARRIER/SEAL DEVELOPMENT AT HI-TEMP INSULATION

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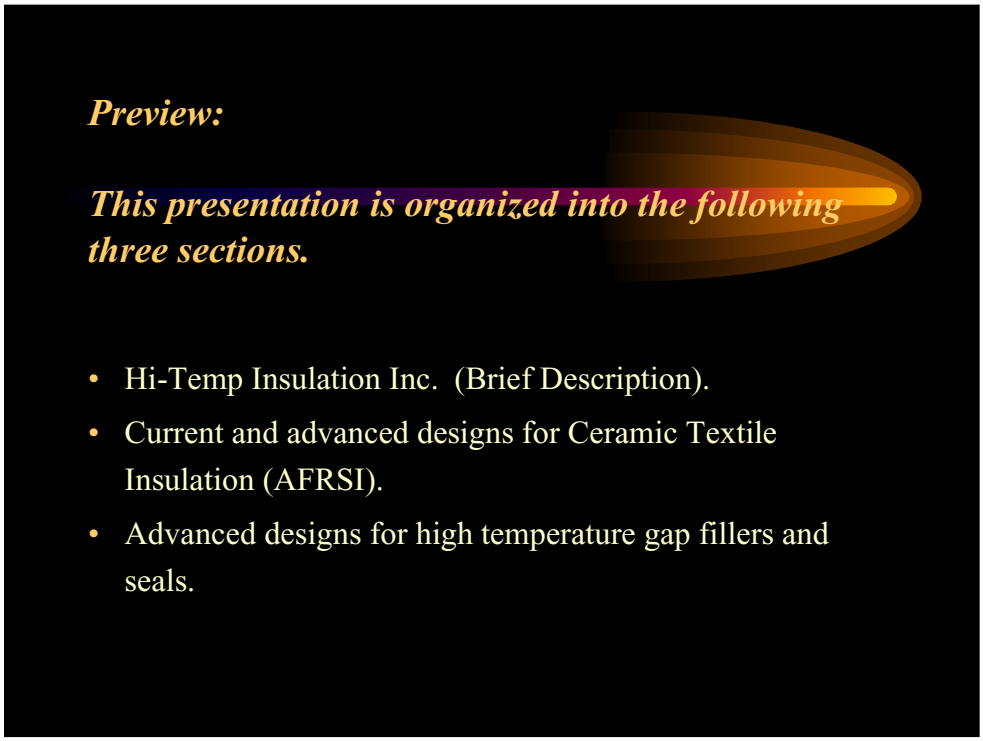
This presentation will provide an overview of thermal barrier / seal development at Hi-Temp Insulation.



Hi-Temp Insulation has provided the Aircraft, Missile and Space Industries with the most innovative designs and dependable products since 1972. Specializing in solving thermal and acoustical problems, our niche is defined be extreme temperatures and limited space/weight, requiring the most efficient insulating materials.

The products we offer are divided into four categories:

1. Metal foil covered insulation blankets are used for protection at high temperatures when fluid resistance and increased durability are critical.

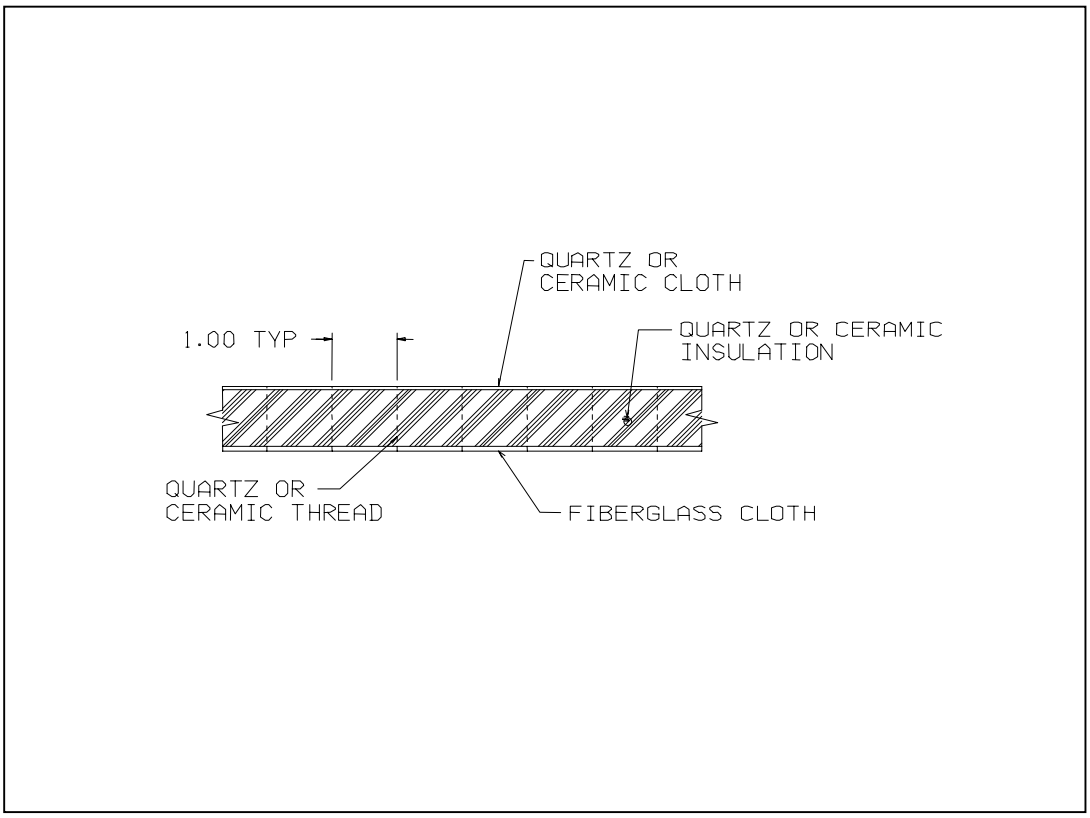
2. Coated cloth, (typically coated with silicone), covered insulation blankets are used in environments under 450°F, and are both fluid resistant and flexible. Adding a ceramic cloth layer, these blankets stop a 2000°F flame for 15 minutes with no burn-through.

3. Film covered insulation blankets offer the same advantages as the coated cloth products, while being lighter weight. These products are used in environments to 600°F.

4. Sewn or quilted insulation blankets are typically used when operating temperatures are over 1200°F. It is this division of Hi-Temp Insulation that fabricated the AFRSI blankets and seals.

Program	Application - Insulate the…	Customer
Space Shuttle	We provide over 70 percent of the insulation for this program.	Boeing (Rockwell) USBI
Delta II & III	Rocket Nozzle, Gimble Boot, Roll Engines, Blast Tube and Wire Harness Assemblies.	Boeing
Delta IV	Main Nozzle, Roll Nozzle, Exhaust Nozzle, and Drain Lines.	Boeing
Atlas 2AR	Helium Tanks, Engine, Fuel Lines and Oxygen Lines.	Lockheed Martin
Atlas 2ARS	Rocket Nozzles, Turbine Exhaust Duct, and Oxygen Fuel Lines.	Lockheed Martin
Atlas III	Engine Nozzle, and LO2 Inlet	Lockheed Martin
RS-68	Hot Ducting, Turbine Duct, Turbine Exhaust Duct, Lox Pump, Fuel Pump and Gas Generator.	Boeing (Rocketdyne)
X-33	Engine, Thermal Protection System (Metal Foil Blankets and AFRSI Blankets), High Temperature Seals.	Boeing (Rocketdyne) Rohr Industries
Space Station	Designing quilted Kevlar / Nextel insulation blankets for protection from micro-meteors.	Boeing (Space)
Satellites	MLI blankets	Lockheed Martin Boeing (Space)

Hi-Temp Insulation participates in most major Space programs. Listed are some of these programs.



Low temperature advanced flexible reusable surface insulation (AFRSI) is currently used on the upper or leeward surfaces of bot the Space Shuttle and the X-33. The AFRSI blankets are rated for continuous use to 1400^0F, while reducing the bond line temperature to 300^0F.

•Insulation - Quartz Felt.

•Outside fabric facing - Quartz cloth.

•Inside fabric facing - Fiberglass cloth.

High temperature AFRSI is currently used on both the leeward surface between the vertical fins and on the base of the X-33. The higher temperatures in these areas are due to the close proximity to the thermal plume from the aero-spike engines. The high temperature AFRSI is rated for continuous use to 2200^0F while reducing the bond line temperature to 300^0F.

•Insulation - Ceramic fiber.

•Outside fabric facing - Ceramic cloth.

•Inside fabric facing - Fiberglass cloth.

Impact resistant tiles are part of a Boeing shuttle upgrade program. Advanced ceramic textile insulation blankets were recently installed to protect the wing leading edge from meteorite impacts. We added layers of ceramic cloth to the current wing leading edge insulation blanket design. This reduces the higher temperatures generated from the impact of meteorites on the shuttle surface, and from the torch conditions that the penetrations in the TPS system create.

On the space station TPS system, we added layers of both ceramic cloth and kevlar cloth. The ceramic cloth cooled the meteorite during impact, and the kevlar, layered behind the ceramic cloth, stopped the penetrations.

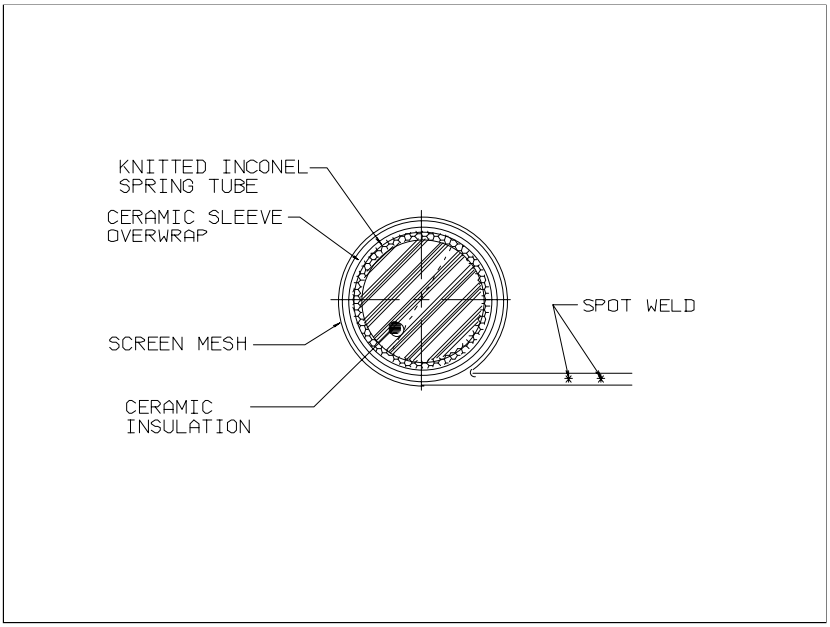
Working with NASA-Ames Research Center, and increased durability and impact resistant ceramic textile insulation was developed called DurAFRSI. This blanket is a hybrid metallic / ceramic insulation that provides both impact resistance and thermal protection.

•Insulation - Ceramic fiber.

•Outside facing - hybrid metallic / ceramic cloth.

•Inside facing - Fiberglass cloth.

Typically, each of the AFRSI blankets discussed are bonded to a composite or aluminum surface with RTV 560. The TPS system must reduce temperatures to protect both the bond line and the vehicle surface. Also, the blankets are typically waterproofed using a process that individually coats each of the insulation fibers preventing the AFRSI from absorbing water. Finally, after installation, a protective ceramic coating is added to the outer surface of the AFRSI blankets.



One very significant difference between the Space Shuttle thermal protection system and the X-33 TPS system is that the X-33 has a "hot-frame" requirement. Since the frame expands and contracts during flight, the TPS system incorporates a variety of seals between the insulation panels to accommodate this movement. The high temperature seal types can be generally grouped into four categories; gap filler, spring seal, spring "P" seal, and screen reinforced seal.

Gap filler seals are the simplest seals we fabricate. They provide good compression but have poor resiliency. They include a ceramic sleeve filled with ceramic insulation. The insulation density varies from 3 to 9 PCF depending on the performance requirements.

•Outer surface – Quarts or Ceramic fabric.

•Core – Ceramic insulation.

To improve the seal's resiliency, an Inconel knitted spring tube is added. The knitted spring tube is overwrapped with a lightweight ceramic sleeve and stuffed with an appropriate density of ceramic insulation. By adding the knitted spring tube and varying the insulation density, we control the seal's thermal efficiency, compressive ability, and it's resiliency or "spring back" characteristics.

•Outer surface – Inconel knitted spring tube overwrapped with lightweight ceramic cloth

•Core – Ceramic insulation.

Hi-Temp Insulation Inc.

Hi-Temp Insulation, Inc. provides the Aircraft, Missile and Space Industries with the most innovative designs and the very best products used to solve thermal and acoustical problems.

The leader in new material use and fabrication techniques; our products are designed to meet the challenge of today's sophisticated requirements.

Our modern 134,000 sq. ft. facility includes a comprehensive range of equipment, storage space, test labs, and manufacturing capability.

Our equipment includes many special machines such as rigidizing rollers for strengthening metal foils; special heated platen press for bonding structural components; heat-sealing machines; seam and spot welders for light gage stainless steel and inconel; high temperature ovens for shaping resin impregnated fabrics; and sewing machines for quilting up to two inches thick.

Specialists in metal foil, soft goods and sewn insulation designs; we have gained considerable experience by providing solutions for a variety of demanding applications.

As a full service manufacturer, Hi-Temp Insulation provides its customers with…

Customer Service

- Our sales and support staff are prepared to meet with you throughout the United States and worldwide to discuss your technical requirements.

Research and Development

- We continue to pursue numerous research and development projects including the best available products for high temperature and fire stop applications.

Engineering

- We have a comprehensive engineering facility which undertakes the complete design and manufacture of products from basic performance requirements.

Production

- We are small enough to be flexible and responsive, and large enough to manufacture a quality product that will satisfy your high standards of production.

Quality Control

- Our strict quality control procedures, satisfying the requirements of DI-9000, ISO-9000 and FAR21.303, track the fabrication process from material selection through final packaging, assuring that critical specifications are met.

AFRSI blankets and high temperature gap fillers and seals, originally developed for use on the Space Shuttle, have significantly improved for use on new generation reusable launch vehicles. This presentation will focus on:

- Original designs used on the Space Shuttle.
- Advanced designs developed for use on the X-33.
- Additional advancements for future use on reusable launch vehicles.

Preview:

This presentation is organized into the following three sections.

- Hi-Temp Insulation Inc. (Brief Description).
- Current and advanced designs for Ceramic Textile Insulation (AFRSI).
- Advanced designs for high temperature gap fillers and seals.

Program	Application - Insulate the...	Customer
Space Shuttle	We provide over 70 percent of the insulation for this program.	Boeing (Rockwell) USBI
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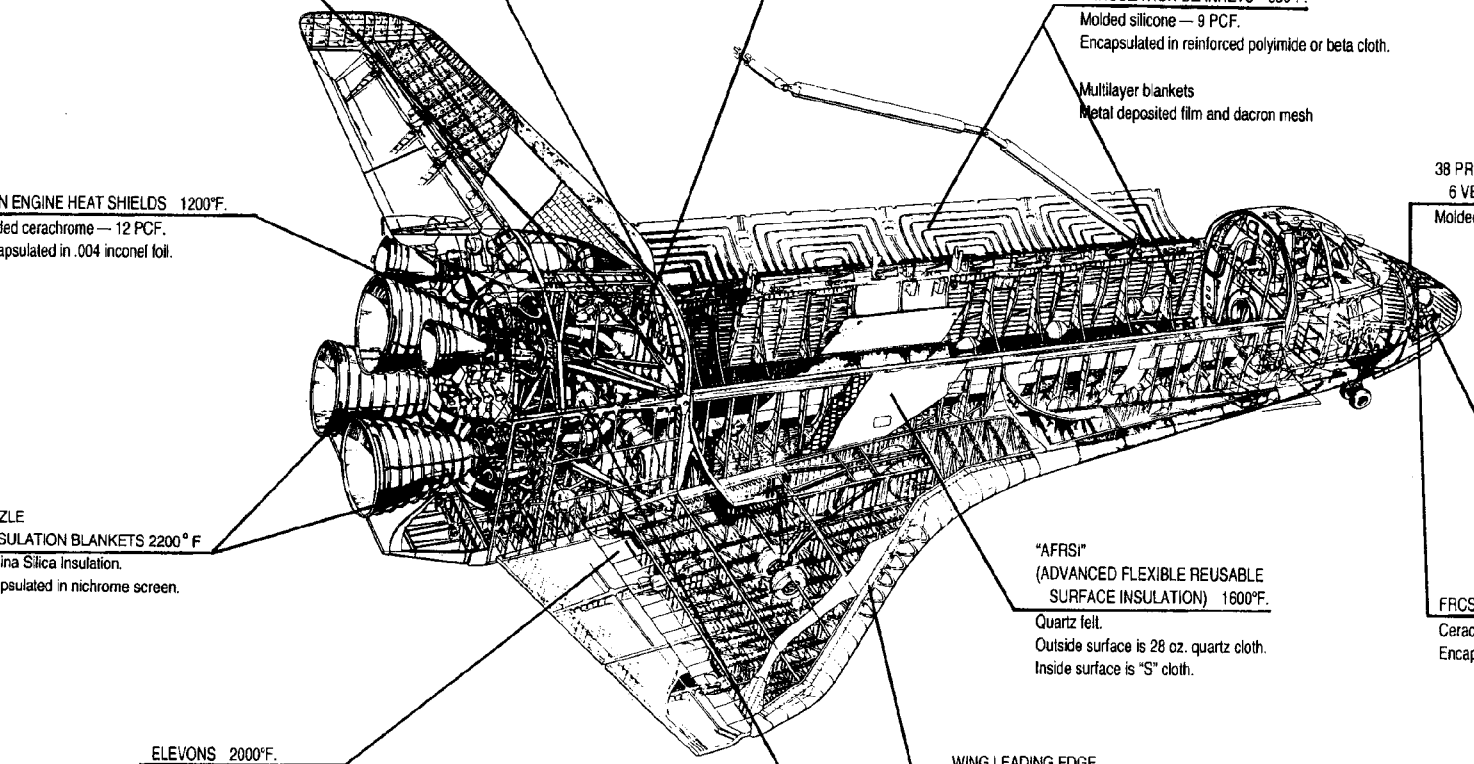
SPACE SHUTTLE



HYDRAULIC SYSTEM LINES −150° to 380°F.
Molded silicone — 3 PCF.
Covered in polyester film.

HYDRAULIC SYSTEM COMPONENTS −150° to 380°F.
Molded silicone — 3 PCF.
Outside surface is .002 stainless steel.
Inside surface is RTV coated molded silicone.

VERTICAL STABILIZER–
MACHINED FITTING 2000°F.
Molded cerachrome — 24 PCF.
Outside surface Haynes 188.
Inside surface .004 inconel foil.

APU EXHAUST DUCTS 1200°F.
Molded cerachrome — 12 PCF.
Outside surface is .004 inconel.
Inside surface is "S" cloth.

PAYLOAD BAY
INSULATION BLANKETS 350°F.
Molded silicone — 9 PCF.
Encapsulated in reinforced polyimide or beta cloth.

Multilayer blankets
Metal deposited film and dacron mesh

MAIN ENGINE HEAT SHIELDS 1200°F.
Molded cerachrome — 12 PCF.
Encapsulated in .004 inconel foil.

38 PRIMARY THRUSTERS,
6 VERNIER THRUSTERS 2000°F.
Molded cerachrome — 24 PCF.

PLUME SHIELDS 2200°F.
Molded cerachrome — 12 PCF.
Outside surface Haynes 188.
Inside surface .004 inconel.

NOZZLE
INSULATION BLANKETS 2200° F
Alumina Silica insulation.
Encapsulated in nichrome screen.

"AFRSI"
(ADVANCED FLEXIBLE REUSABLE
SURFACE INSULATION) 1600°F.
Quartz felt.
Outside surface is 28 oz. quartz cloth.
Inside surface is "S" cloth.

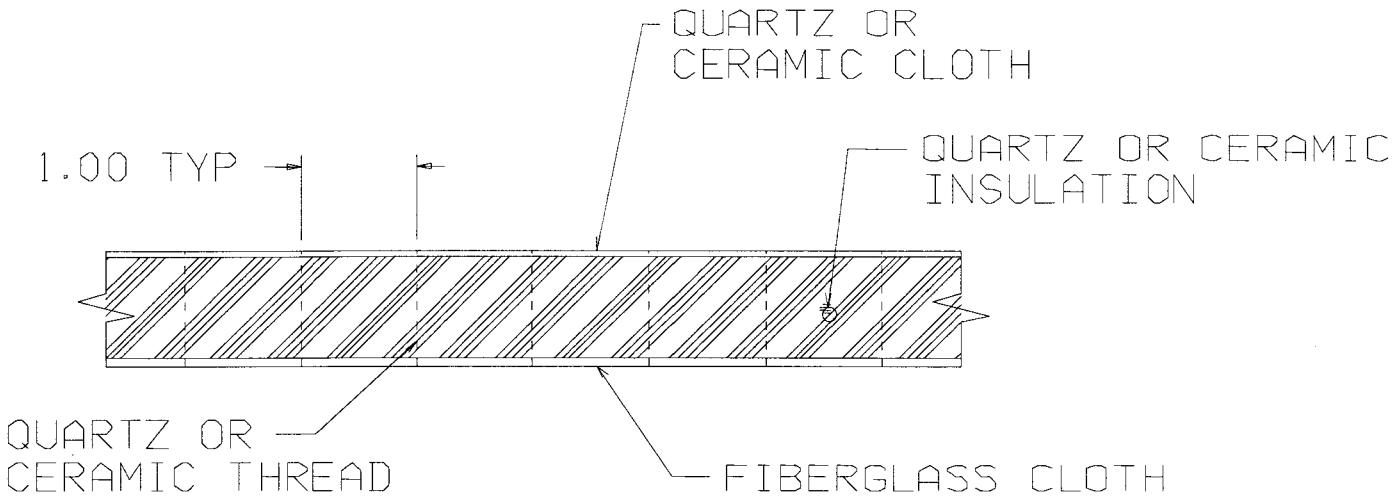
FRCS THERMAL CONTROL 1000°F.
Cerachrome — 12 PCF.
Encapsulated in .003 inconel.

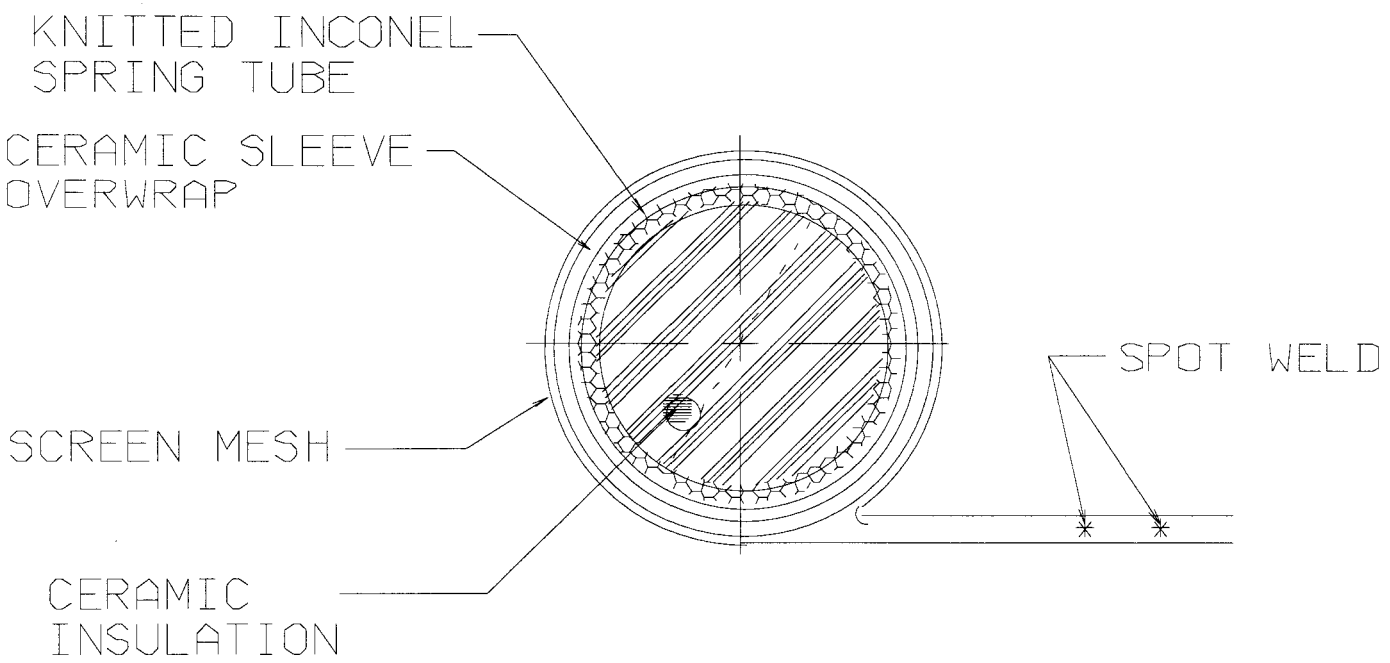
ELEVONS 2000°F.
Cerachrome — 24 PCF.
Encapsulated in .004 inconel foil.

WING LEADING EDGE
INSULATION PANEL 2300°F.
Cerachrome — 8 PCF.
Encapsulated in .004 inconel foil.

APU FUEL TANK 360°F.
Molded silicone — 3 PCF.
Outside surface .002 stainless steel.
Inside surface molded silicone.

*Temperatures are for operating conditions,
not minimum or maximum capability.


QUARTZ OR
CERAMIC CLOTH
1.00 TYP
QUARTZ OR CERAMIC
INSULATION
QUARTZ OR
CERAMIC THREAD
FIBERGLASS CLOTH


KNITTED INCONEL
SPRING TUBE
CERAMIC SLEEVE
OVERWRAP
SPOT WELD
SCREEN MESH
CERAMIC
INSULATION

Summary:

This presentation focused on the following three topics.

- Hi-Temp Insulation - uses the most efficient materials to protect from extreme temperatures.
- Current and advanced designs for AFRSI - quilted quartz, ceramic and metallic materials used as TPS on reusable launch vehicles.
- Advanced designs for high temperature gap fillers and seals - quarts and ceramic facings with inconel knitted spring tube and ceramic insulation, optimize both compression and resiliency.